INTERNATIONAL JOURNAL OF ADVANCE RESEARCH, IDEAS AND INNOVATIONS IN TECHNOLOGY

ISSN: 2454-132X
Impact factor: 6.078
(Volume 6, Issue 4)
Available online at: www.ijariit.com

The growth of lettuce under T5 led lamps in non-circulating hydroponics

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ABSTRACT

Lettuce is grown hydroponically by both circulating and non-circulating hydroponics. The present experiment was done under wooden built cabin, stacking was done under iron racks. 1-liter bottles were covered with the black polythene covers to avoid the algae formation. Commercially available nutrient solution was grown in the first trail. Each rack was fitted with 3 T-5 led lamps equally spaced along the width of the rack. Each bottle was aerated with an air pump. Seeding was done directly in jiffy plugs and supported with net pots. Purified water was used for both nutrient solution and watering the seedlings. Basic N-P-K nutrition was given until seedling was grown and was transplanted when the seedlings obtained 3 leaves. Covered bottles were filled with nutrient solution leaving a 2 cm gap from the top of bottle. Net cups were inserted with plants, 3cm of the net cups was covered with nutrient solution and the yield was measured. The PH and TDS was maintained an optimal range over the growing period. In the second trial seeds were directly placed in the sterilized growing medium, lighting was increased by increasing one light in the seedling rack and seedling stage was measured in terms of the health of the seedling.

Keywords— *Non-circulating hydroponics, Indoor Farming, T5 LED, Lettuce, Hydroponic Nutrients.*

1. INTRODUCTION

Hydroponics is a technique of growing plants in nutrient solutions with or without the use of an inert medium such as gravel, vermiculite, rockwool, peat moss, saw dust, coir dust, coconut fibre, etc. to provide mechanical support. The non-circulating hydroponics is a booming commercial method of growing leafy and lettuce varieties. For total growth period of the crop it is immersed in the nutrient solution and is grown to the mature stage until harvested. No extra operations are done in between unless filling of solution when completed. There is no extra operational cost incurred in rotation of nutrient, but electricity costs for maintenance of plant growth parameters such as light, humidity, aeration are incurred and no particular studies is done on per yield(kg) of lettuce grown. Water use efficiency of less than 20 liters per kg of lettuce are common and efficiency as low as 11 liters per kg of lettuce has been recorded (Kratky *et al*., 2008).The mixture of major and minor nutrients was given in the range of 2.4 to 4 liters per kg of lettuce and yield was measured. The pH of the nutrient solution is maintained at a range of 6.0-6.5 and TDS in between 560-780 PPM. The major and minor nutrients include 13 essential nutrients which the plants needed to thrive, such as Primary Nutrients (needed in large amounts): Nitrogen (N), Phosphorous (P), Potassium (K),Secondary Nutrients (needed in smaller amounts): Sulfur (S), Calcium (Ca), Magnesium (Mg) and Micronutrients (needed in trace amounts): Zinc (Zn), Iron (Fe), Copper (Cu), Manganese (Mn), Boron (B), Molybdenum (Mo), Chlorine (Cl).

The above elements are being given by the respective chemicals which contain those element traces in the prefixed amounts and experimented and proved to be the good acting one. The pH levels are adjusted by lowering the pH level by adding diluted phosphoric acid to the solution. To raise the pH level, diluted potassium hydroxide is added to the solution. Day to day pH and TDS was observed with pH and TDS meters.

2. MATERIALS AND METHODS

A closed cabin of wooden wall structure with an internally fitted air conditioner for maintaining temperature and an Ultrasonic fogger was used. The middle of the room contains 2 iron racks of dimension 6ft X 3ft of 6 steps which is observed in the fig-1. Each step was fitted with 3 T5 LED lamps (for trail 1) equally spaced along the width which is observed in the fig-3. One Step was spaced closer towards the light for seedling stage. Each stage was equipped with 12 containers each containing one lettuce plant. Each container was of 1-liter capacity covered with a black cover for restricting the algal growth in the container which can be observed in the fig-2. The net cup in the container was immersed upto 4 cm of nutrient solution for the plant to uptake nutrient. Nutrient uptake into the substrate was accomplished by capillary action and roots started emerging out of the net cups slot and plant starts to grow. The structure had an advantage that it utilized the space vertically adopting more un-utilized area for the plants to grow and increased the spacial efficiency of the area chosen. The stacking utilized this place to grow more plants and reached to heights as much as possible.

Fig.1. Rack system with T5 Grow Lights

Fig. 2. Covered container Used for Growing Lettuce

Fig. 3. Stacking system with grow lights.

Experiment trial-1:

The experiment was conducted at Vignan's Deemed to be University, Vadlamudi, Guntur (U-Block, latitude 16°13'59.7"N longitude 80°33'01.8"E).Trial -1 was started on 2nd July 2018. The temperature was maintained by the air conditioner, and relative humidity was regulated by the ultrasonic fogger. The temperature was maintained at a range of 24-26°C when air conditioner was turned on. Air conditioner was operated for 8hrs a day during sunny days from 10:00 am to 5:00 pm. The remaining time was left over and temperature was altered from 26-33°C in a day. The relative humidity was maintained at range of 53-55% using an ultrasonic humidity of capacity fogging 2lit of water per hour. 3-inch net cups were taken and jiffy plugs of 3 inches were taken. Mineral drinking water was used for expanding the dry jiffy plugs.

A small punch hole was made and lettuce seeds were placed and covered with the jiffy substrate. 3 rows of pots in a stack each row under each light was kept which can be observed in fig-4. Light was operated for 16 hours per day and 8 hours of darkness was provided for plants. Primary N-P-K nutrient solution was given until the seedlings obtained approx. 3 leaves. The solution was also prepared with the purified mineral water. Sides of the rack were covered with newspaper to avoid light to escape to the surroundings and provide maximum incident radiation to the plants. After 4-5 days the seedlings started to raise slowly which is observed in the figures 5,6,7. The seedlings were kept under these lights without immersion into the solution until seedlings acquire 3-4 leaves and now these were ready for transplantation into containers containing nutrient solution. In each container a blend of 1 lit nutrient solution and net cups were immersed from the hole placed from the cap and was adjusted in such a way that 4cm of the net cup was in the nutrient solution. Each container was the blend of both major and micro nutrients in a diluted form as per concentration of the nutrients prepared. The pH and TDS were measured 2 times in a day and was adjusted in the mentioned optimal range in each container.

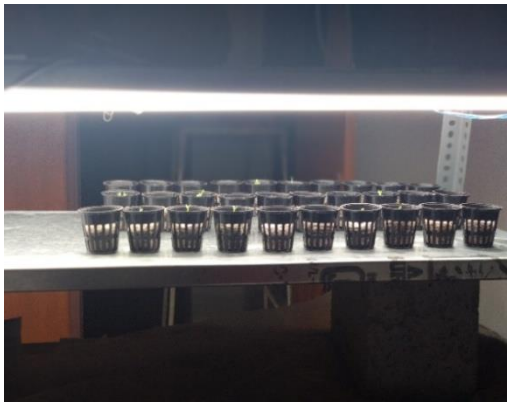

Fig. 4. Tapered net pots arranged after seeding

Fig. 5. Seedlings in the expanded jiffy plugs

Fig. 6. The expanded 2 leaf seedlings

Fig. 7. The expanded 3-4 leaf seedling stage

Experiment trial-2:

In trial 2 there are some changes made in the system. The main aim of the trail-2 was to produce non elongated healthy seedlings. So, jiffy plugs were eliminated due to some inadequacy during seeding and root system failed to come out properly. The sterilized cocopeat was used as a medium and was watered with mineralized purified water. The coco peat was squeezed harder until the absorbed water was removed and cocopeat is just in moistened state and there available water was present for the seeds to raise. Round seed trays were used for growing seedlings which can be observed in the fig. 8,9and were transplanted to cocopeat filled net cups and then grown with primary N-P-K nutrients after seedlings acquired 2-3 leaves. The seedlings started to raise slower, and seedlings were remained in the seed trays until 7 days. Now these were slowly transplanted into the nutrient solution containers. The net cups were immersed in such a way that 4cm of net cup was in nutrient solution.

The lighting was kept in the same in this condition and side of the rack was covered with newspaper so that there is no light escaping to environment and maximum amount of incident light is available for seedlings, and no change in the nutrient amounts was given and lettuce was harvested after 55 days. Light was operated at a rate of 16 hours per day and 8 hours of darkness is provided for plants. The temperature was maintained in the range of 24-33^{o}C due to cyclic on and off of the air-conditioner. The lettuce showed the elongation and was continued till the harvest time which can be observed in the fig. 10,11. The relative humidity was maintained at 55%. The pH and TDS were measured 2 times a day and adjusted accordingly. The nutrient solution was constantly filled when it had reached to bottom.

Fig. 8: Seedling done in seed tray with growing medium

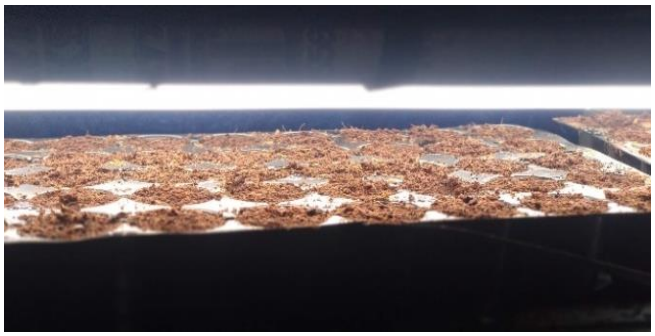

Fig. 9. Arrangement of seed tray under the light

Fig. 10. Elongated seedlings in the seed tray

Fig. 11. Raised seedlings in the seed tray

Experiment trial-3:

In trial: 3 lot of changes was incorporated in the system. The main aim of the trail 3 was to produce non elongated healthy seedlings and 5 leaf lettuce. The sterilized cocopeat was used as a medium and watered with mineralized purified water. The cocopeat was squeezed harder until are the absorbed water has removed and coco peat was just in moistened state and there is ample available water was present for the seeds to raise. This coco peat was directly filled into the net cups which can be observed in the fig. 12,13andseeds were directly sown in these net cups. These cups were now placed under the lights. Seedlings were then grown with primary N-P-K nutrients after seedlings acquired 2-3 leaves. Now these were slowly transplanted into the nutrient solution containers.

The net cups were immersed in such a way that 4cm of net cup is in nutrient solution. The lighting has increased to 4 in this condition and side of the racks were covered with newspaper to remove possibility of escaping of lightand maximum amount of light is available for seedlings,Light was operated at a rate of 16 hours per day and 8 hours of darkness is provided for plants. In this trial the lighting in the rack was increased to 4 rather than 3 in previous trial. The temperature was maintained in the range of 24-33ºC due to cyclic on and off of the air-conditioner. The lettuce showed no elongation and it was observed till the 5-leaf stage, this result can be observed the fig. 14,15. The relative humidity was maintained at 55%. The pH and TDS were measured 2 times a day and adjusted accordingly. The nutrient solution was constantly filled when it had come to bottom. The traces of Calcium Nitrate, Potassium Nitrate, Sulphate of Potash, Monopotassium Phosphate, Magnesium Sulphate, Chelated Iron, Zinc Sulphate, Manganese Sulphate, Copper Sulphate, Boric Acid, Sodium Molybdate was used in making nutrient solution for all the major and micro nutrients that are needed for growing plants.

Fig. 12. Seeds directly placed in the netpots with Growing medium

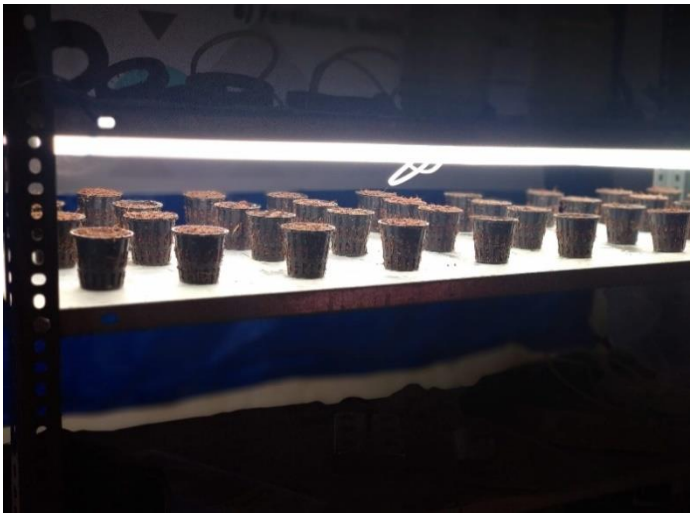

Fig. 13. Net pots directly placed under grow lights

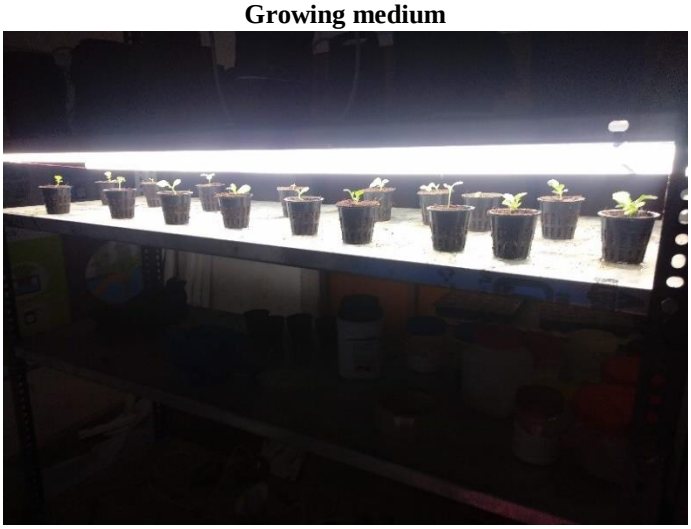

Fig. 14. Non elongated seedlings under lights

Fig. 15. Non-elongated 4 leaf stage seedling

3. FINDINGS

In each trial some development was observed and healthy lettuce was grown at indoors and studywas performed only upto a particular stage. Irrespective of already proven commercial systems of growing lettuce indoors it was an attempt made in Andhra Pradesh (South India) according to the conditions prevailing here. The purpose of the above work is to grow the plants successfully upto a 20-day stage and this was successful in the last trial made. No further work was done on calculating the yield of the grown lettuce on the present system but it describes the growth nature of seedlings upto a particular stage. This soil less method has proven to decrease the feasibility of relying of agriculture land to grow crops and arises a concept of "grow your own, feed by own" where every human being has an opportunity of growing their own produce in their living area in a small area with electricity facility and ventilation without depending on sunlight even.

4. CONCLUSIONS

Experiment trial-1:

The germination time of lettuce seeds was faster in case of jiffy plugs and drudgery in sowing seeds was less and was easier to sow.The roots didn't emerge out properly when transplanted to nutrient containers. The pH and TDS tend to increase with decrease in the nutrient solution in the containers. There was problem of blight which can be observed in the fig. 19 due to non-airflow in the cabin when air conditioner was not turned on. The elongation of seedlings occurred when 3 led lamps was arranged per stack. The elongation even prevailed at the time of harvesting stage.

Fig. 16. Healthy 7 leaf stage lettuce

Fig. 17. Elongated 5 leaf stage lettuces

Fig. 18. Elongation of stem in lettuce

Fig. 19. Formation of blight on the surface of the leaf

Experiment trial-2:

When seeds were sown in seed trays germination time was slower as compared to seeds sown in jiffy plugs and the seedlings were healthy and proper root system was formed as compared to seedlings sown in jiffy plugs. The elongation was also continued in this trail. Root system after the transplantation into the nutrient container was good as compared to the plants in jiffy plugs and the plant has shown vigorous growth during maturity stage.

Fig. 20. Elongation of leaf stem

Fig. 21. Uneven Folding of the leaves

Experiment trial-3:

No elongation of the seedlings was observed when the lighting was increased, which indicated this lighting was sufficient for the seedlings to grow. A good root system has been observed rather than the previous trails because the is no pulling of the plant for transplantation. Due to change in the nutrition the plants responded in the very good way even at the 6-leaf stage no elongation was observed. The plants were much healthier than the previous trials at this stage and a very large amount of root system was observed in the nutrient containers.

Fig. 23. Healthy non elongated seedlings

Fig. 24. Non-Elongated 5 leaf stage lettuce

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